9 Noise and Vibration

Contents

This page is intentionally blank.

9 Noise and Vibration

9.1 Executive Summary

9.1.1 This chapter evaluates the noise and vibration effects of the Proposed Development. The levels of noise and vibration likely to occur at local residential properties as a result of the operation of the proposed wind turbines have been assessed in respect of the Proposed Development in isolation, and cumulatively with other local wind farm developments. Potential noise and vibration effects from construction activities and any borrow pit workings have also been assessed.

9.1.2 The assessment in this chapter was carried out using the noise data for the Siemens Gamesa 3.4-132 turbine which was determined to be the 'worst case', *ie* noisiest turbine, from a range of candidate turbines considered for the Proposed Development.

9.1.3 The noise and vibration assessment was conducted on the basis that the noise limits in the planning conditions for the neighbouring, and recently consented, Douglas West site will be appropriate to the Proposed Development. The assessment has shown that the Proposed Development will meet all the conditions regarding noise and vibration contained within the recent consent for wind energy development on the adjacent site, and it is concluded that there will be no significant residual effects on nearby residential properties in terms of noise immission or ground-borne vibration.

9.2 Introduction

9.2.1 Background noise levels were surveyed in 2012 and 2015 in connection with the adjacent (consented) Douglas West Wind Farm which was also developed by 3R Energy. The results of the 2012 and 2015 surveys were considered appropriate for use in the recent applications for the neighbouring Douglas West project in 2015 and 2017. The most recent application for a tip height increase to 149.9 m received planning permission on 2 May 2018, reference CL/17/0477.

9.2.2 No further background noise surveys have been carried out in connection with the Proposed Development, because the background levels, i.e. the levels with no operational turbines, are no longer measurable. Noise surveys at locations already affected by existing wind energy developments are proscribed by ETSU-R-97 at page 58 (in relation to cumulative impact) which specifically states that an existing wind farm "*should not be considered as part of the prevailing background noise*". That paragraph of the appropriate guidance also makes it clear that absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area in order to assess the likely impact of the wind turbine generators on noise-sensitive receptors. Planning conditions were set by South Lanarkshire Council (SLC) when planning permission was granted for the neighbouring Douglas West project in 2018, and these noise limits and conditions previously set down remain appropriate for the protection of nearby receptors in respect of the Proposed Development.

9.2.3 The assessment is made against the guidelines available for wind energy developments as noted in Section 9.3.5 below. Particular attention is paid to the ETSU-R-97 report *The Assessment and Rating of Noise from Wind Farms*, the latest *Onshore wind energy planning conditions guidance note* (Renewables Advisory Board and the Department for Business, Enterprise and Regulatory Reform, BERR) and the Institute of Acoustics' (IOA) *Good Practice Guide on the application of ETSU-R-97*, May 2013 together with its supplementary guidance notes published in 2014.

9.3 Legislation, Policy and Guidelines

Legislation

9.3.1 The *Control of Pollution Act 1974* sets out legislation relating to noise from construction sites, from plant and machinery and from other sources, and discusses Best Practicable Means and codes of practice for minimising noise.

Planning Policy

9.3.2 Energy policy in Scotland has been specifically reserved to the UK parliament, but planning is a matter that has been devolved to the Scottish Government. The Scottish Government has previously stated that *ETSU-R-97*, supplanted by guidance on best practice, should be used to assess environmental noise from wind turbines (Scottish Government, 2014).

9.3.3 Chapter 5 sets out the planning policy framework that is relevant to the EIA. Of relevance to the noise and vibration assessment presented within this chapter, regard has been had to Paragraph 169 of *Scottish Planning Policy*, which notes that noise impacts on individual dwellings and communities are to be considered in development management for energy developments.

9.3.4 Relevant SLC policy relating to the assessment of noise from onshore wind farms is found in the South Lanarkshire Local Development Plan (2015), and SLC Supplementary Guidance 10 Renewable Energy (2015). Part 10b of the assessment checklist (Table 7.1) states that "*all applications for wind turbine developments should be accompanied by a site specific noise assessment*".

Guidance

9.3.5 Due notice has been taken of the following guidance and recommendations:

- The Working Group on Noise from Wind Turbines The Assessment & Rating of Noise from Wind Farms (ETSU-R-97) (1996)
- (Institute of Acoustics, 2013) Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (IOA Good Practice Guide) and associated Supplementary Guidance Notes
- Planning Advice Note (PAN) PAN1/2011 Planning and Noise. Information and advice on noise impact assessment methods is provided in the associated Technical Advice Note Assessment of Noise
- (Institute of Acoustics, 2009) Bulletin Article Volume 34 No. 2, March / April 2009
- ISO 9613-2:1996 Acoustics -- Attenuation of Sound during Propagation Outdoors -- Part 2: General Method of Calculation

9.4 Consultation

9.4.1 The Environmental Health department at SLC was consulted before the original background noise surveys most appropriate to the Proposed Development were carried out in 2012 and 2015 for the neighbouring Douglas West Wind Farm. The Environmental Health Officer (EHO) was consulted again in 2017 in connection with the tip height extension application for the Douglas West Wind Farm (CL/17/0477) in order to discuss the scope of any further background noise survey work and whether the results of the 2012 and 2015 surveys could still be considered valid. In that case, it was agreed that no repeat background noise monitoring should be undertaken at any locations because so many additional turbines had been brought into operation in recent years.

9.4.2 Through consultation with the SLC Environmental Health department on the Proposed Development it was agreed again that it was neither necessary nor advisable to repeat the background noise measurements at any locations because additional turbines had since been brought into operation. This approach was central to the Scoping Opinion from South Lanarkshire Council in a letter dated 14 February 2019 (refer to Appendix 4.2) and was agreed in direct communication with the EHO (refer to Appendix 4.3). In accordance with ETSU-R-97 Guidance, and as agreed with the SLC EHO, additional background noise measurements have therefore not been undertaken in connection with the Proposed Development.

9.5 Assessment Methodology and Significance Criteria

Study Area

9.5.1 Preliminary noise predictions for a matrix of thirteen turbines indicated the area within which a noise immission level of 35dB $L_{A90,10min}$ could be exceeded. The extent of this area depends on the disposition of the nearest turbines to the receptor in question, and the area possibly affected by noise from the Proposed Development could extend to 5km from the site boundary, although at such distance the noise immission level will be considerably less than 35dB. Within the area subject to more than approximately 30dB, the nearest noise-sensitive locations to any turbine were identified so that noise predictions could be made for all residential properties in accordance with the relevant guidance. It is worthy of note that in any given direction from the Proposed Development, if the noise impact is acceptable at the nearest noise-sensitive location then it must necessarily also be acceptable at more distant locations.

9.5.2 Given that the separation distances between the Proposed Development and the nearest residential properties are of the order of hundreds of metres, vibration effects would be imperceptible, so only a brief qualitative vibration assessment was conducted. The levels of vibration depend not only on the input excitation, but also on the ground conditions close to the surface (in the unconsolidated layer) and the nature of the property in which vibration might be detected. None of these can be predicted other than in terms of the order of magnitude.

Methodology

PAN45 and Subsequent Web-based Guidance

9.5.3 Until early 2011 Planning Advice Note 45 specified the issues that should be taken into account by local planning authorities when assessing the development of renewable energy projects. Regarding wind turbines in particular, the guidance stated that the framework for the measurement of wind farm noise in the ETSU-R-97 report (see below) should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from such developments, until such time as an update was available. PAN 45 also cited the UK Government's statement regarding the findings of the Salford University report into aerodynamic modulation of turbine noise, which concludes that there is no evidence of health effects arising from infrasound or low frequency noise generated by turbines.

9.5.4 In March 2011 PAN 45 was revoked and replaced by web-based planning guidance on renewable energy. This web-based guidance refers to ETSU-R-97 as a framework for the measurement of wind farm noise which should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments, until such time as an update is available. It goes on to cite ETSU-R-97, stating that it *'…gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable burdens on wind farm developers, and suggests appropriate noise conditions'*.

ETSU-R-97

Background noise

9.5.5 A development of this type should be assessed using ETSU-R-97, since the current web-based guidance recommends this approach. The report describes a framework for the measurement of turbine noise and indicates desirable noise levels, so that without placing unreasonable restrictions on wind energy developments, neighbouring residential properties can be protected from excessive noise. A primary objective of the report is to suggest noise limits in a form suitable for adoption as planning conditions. The Noise Working Group that produced the report considered that absolute noise limits regardless of wind speeds were not suited to wind energy schemes in the UK, and that it was more appropriate in the majority of cases to set noise limits relative to background noise.

9.5.6 The background noise levels are to be measured over a range of wind speeds so that the impact of turbine noise, which is also wind-speed dependant, can be evaluated. The parameters to be

measured include the equivalent continuous noise level and the 90 % exceedance level. The equivalent continuous noise level L_{Aeq} is the noise level in 'A' weighted decibels which, if present for the entire measurement period, would produce the same sound energy to be received as was actually received as a result of the real, time-varying signal. The abbreviation often includes a specification of the time period (such as 1 hour, or 5 minutes) indicating the period of time to which the measured value has been normalised; for example, '$L_{Aeq,1h}$'.

9.5.7 The statistical indicator of the form L_n resulting from an environmental noise measurement is the level which was exceeded for *n* percent of the measurement period. Thus, an L_{A90} of 40 dB means that an A-weighted sound pressure level of 40 dB was exceeded at the microphone for 90% of the measurement period. Any value of *n* between 0 and 100 is meaningful, but the indices most widely used in the UK are L_{A90}, L_{A50} and L_{A10}. The L_{A90} index is generally taken to be representative of the steady background noise level. The L_{A50} is the arithmetic average of all the instantaneous values during the measurement period. The principal use of L_{A10} is in the assessment of road traffic noise. Again, the time period over which the measurement took place can be specified, so the $L_{A90,10min}$ is the level which was exceeded for 90 % of a ten-minute measurement period: in other words, the level was exceeded for nine of the ten minutes.

9.5.8 One of the most important recommendations in the ETSU-R-97 report is that the statistical index $L_{A90,10min}$ should be used for both the background noise and the wind farm noise. This allows reliable measurements to be made without them being corrupted by louder, transitory noise events from other sources, which would be unavoidable in the countryside. The report notes that for a typical turbine the $L_{A90,10min}$ is between 1.5 and 2.5 dB lower than the L_{Aeq} over the same measurement period. This is worthy of note because for conventional noise measurements in the environment, the L_{Aeq} index is generally regarded as the most appropriate descriptor, and it is normal practice to use it when noise limits are being set. In the present assessment, a constant difference of 2dB between the $L_{A90,10min}$ and the L_{Aeq} is assumed.

9.5.9 A methodology is provided in ETSU-R-97 for the measurement of background noise levels under various wind conditions. The report recommends that data which may be corrupted by extraneous noise sources, including periods when rain falls or when watercourses have abnormally high flows, should be discarded. At all times, the noise levels measured in the environment are to be correlated with wind speed measurements at the site, at a reference height of 10m above ground. Because the noise levels can vary by several decibels at any given wind speed, a curve is to be fitted to the raw data (having discarded measurements that were possibly rain-affected, as noted above) in order to determine the typical variation in background noise level with wind speed. The exercise is carried out for 'quiet' daytime amenity periods and night-time periods, defined as follows. Daytime amenity periods are from 18.00h to 23.00h on weekdays, 13.00h to 23.00h on Saturdays, and all day Sunday. Night-time is between 23.00h and 07.00h daily. All other periods (weekdays and Saturday mornings) are defined as normal daytime, when it would be expected that the ambient noise levels may be somewhat elevated because of human activity, distant road traffic, and natural noise sources.

9.5.10 No specific method is prescribed for the calculation of turbine noise, although there is a basic requirement for the sound power level of the machine to be determined by a standard test method (such as the IEA Recommended Practice). It should be noted that background noise levels are to be determined by best-fit curves through the survey data once extraneous data points have been removed. The ETSU-R-97 report has been supplemented with good practice guidance published by the IOA; this is described below.

Noise Limits

9.5.11 The practice of controlling wind turbine noise by means of noise limits at the nearest noise-sensitive properties is appropriate to the Proposed Development and this approach was agreed with SLC. Noise limits should be applied to external locations and should apply only to those areas frequently used for relaxation or activities for which a quiet environment is highly desirable. Noise limits were set relative to the background noise at the nearest noise-sensitive properties. Thus, the limits reflect the variation in both turbine source noise and background noise with wind speed. According to *ETSU-R-97* and *RAB/BERR* guidance, separate noise limits should apply for daytime and for night-

time, because during the night the emphasis should be on preventing sleep disturbance rather than protecting external amenity. Absolute noise limits and margins above background should relate to the cumulative effect of all turbines in the area contributing to the noise received at the properties in question. Noise from the turbine or combination of turbines should be limited to 5 dB above background for daytime and night-time, remembering that the background level of each period may be different.

9.5.12 The day-time level of the $L_{A90,10min}$ of wind farm noise should normally be limited to an absolute level within the range 35 to 40 dB or a wind-speed-dependent limit, whichever is the higher. Wherever the limit is set, the intention is to offer a reasonable degree of protection to the neighbours of turbines without placing unreasonable restrictions on developments.

9.5.13 A lower fixed limit of 43dB is recommended for night-time. This was originally based on a sleep disturbance criterion of 35dB(A) with an allowance of 10 dB for attenuation through an open window (free field to internal) and 2 dB subtracted to account for the use of $L_{A90,10min}$ rather than $L_{Aeq,10min}$.

9.5.14 Both the daytime and night-time lower fixed limits can be increased to 45 dB to increase the permissible margin above background where the occupier of the property in question has some financial interest in the project.

Guidance on the use of ETSU-R-97

Acoustics Bulletin Article

9.5.15 After some years of applying the ETSU-R-97 recommendations, there was a perceived need to update the guidance in order to keep it relevant to modern large turbines. A panel of acoustics practitioners in the field held a number of discussions, the product of which was an agreed procedure published in *Acoustics Bulletin* in the March/April 2009 issue (volume 34, number 2). In the years between the appearance of that publication and the date of this planning application, two enhancements or clarifications of *ETSU-R-97* in the article have received widespread acceptance among local planning authorities and at Public Inquiries into wind farm applications. The enhancements relate to *(i)* the issue of site-specific wind shear and *(ii)* the assumptions to be made when predicting turbine noise at remote locations. These topics are also dealt with in the IOA Good Practice Guide.

IOA Good Practice Guide (2013)

9.5.16 The IOA Good Practice Guide includes a number of important recommendations, many of which originally appeared in the *Acoustics Bulletin* article of March/April 2009. The guide presents current good practice in the application of the *ETSU-R-97* assessment methodology for all wind turbine developments above 50 kW, reflecting the original principles within that guidance and the results of research and experience since its 1996 publication. The document was prepared by an IOA working group but further comments were received from the relevant UK Government Oversight Group at DEFRA and absorbed into the Guide.

9.5.17 As far as the Proposed Development is concerned, the Guide is particularly relevant to the consideration of turbine noise emission characteristics (noise input data) and to the determination of background noise levels and wind speeds, and thus noise limits. A method of allowing for wind shear in situations where a full height meteorological mast is not available is also recommended in the Guide. Summary points are provided as numbered Summary Boxes (SB): those relevant to the present study are provided below with explanation. Additional supplementary guidance notes, published separately, expand on some of the aspects considered.

9.5.18 SB2 states that the study area should cover at least the area predicted to exceed 35dB L_{A90} at up to 10m/s wind speed from all existing and proposed turbines. There is no requirement to consider noise levels at wind speeds above 10m/s because the subject turbine reaches its maximum noise output at a lower wind speed than 10m/s (derived at 10 m height), and its wind speed versus noise characteristic reaches a plateau level. SB3 requires that any contribution to background noise levels

from an existing wind farm must be excluded when assigning background noise and setting noise limits for a new development.

9.5.19 SB4 relates to the selection of background noise monitoring locations. SB6 confirms that surveys may be carried out at any time of year. SB7 dictates the standard of measurement equipment to be used, and SB8 informs the choice of measurement locations. SB9 requires the correlation of noise measurements with standardised 10m wind speed, and SB10, SB11 and SB12 give further recommendations for the conduct of background noise surveys and their duration.

9.5.20 SB13 confirms that the definitions of 'amenity hours' and 'night-time hours' in ETSU-R-97 remain applicable. SB14 requires the removal of data showing the presence of noise sources 'not common to the representative measurement locations', and SB15 recommends that the 'dawn chorus', where present, should also be removed from the data set. SB16 formalises the removal of rain-affected data, and SB17 allows the routine inclusion of noise from rush hour traffic. SB18 is a recommendation for data analysis by regression but states that the order of that regression depends on the nature of the noise environment.

9.5.21 SB20 deals with the prediction of noise immission levels from wind turbines. In summary, it confirms the recommendations of the *Acoustics Bulletin* article of March/April 2009 in respect of the difference between L_{A90} and L_{Aeq}, the adoption of a ground factor *G* of 0.5, the inclusion of a margin of uncertainty in the turbine noise emissions, together with a statement of its robustness, and the basic parameters for source and receiver heights and atmospheric conditions.

9.5.22 SB21 describes the issues in cumulative noise assessment, where a new wind energy development is proposed in an area where one or more turbines are already operational or proposed.

9.5.23 Under Section 7, Other Guidance, the IOA Guide covers points including planning conditions, (of which a sample is provided), and states that the evidence in relation to 'excess' or 'other' amplitude modulation (AM) is still developing. At the time of writing, current practice is not to assign a planning condition to deal with AM, because it has not proved possible to develop a workable and valid form of condition. An IOA Working Group has been set up to discuss and establish a workable metric for the detection and definition of AM.

9.5.24 Six Supplementary Guidance Notes are referred to in the IOA Good Practice Guide. Four of these were published in July 2014, and the other two in September 2014. Supplementary Guidance Notes numbers 1 to 4 inclusive are applicable to the present assessment: they relate to data collection, sound power level data, data processing and filtering, and the derivation of wind shear.

Significance Criteria

9.5.25 Predicted noise levels which exceed relevant limits at noise-sensitive receptors, calculated by the above methodology, are considered to be significant. Noise levels which do not exceed the relevant limits at noise-sensitive receptors are considered to be not significant.

9.6 Baseline Conditions and Noise Limits

Dates

9.6.1 The first noise survey campaign (three locations) began on Tuesday 03 July 2012 and was completed on Wednesday 01 August 2012. The second noise survey began on Thursday 26 March 2015, although wind data did not become available until Monday 30 March. The survey was completed on Monday 27 April 2015. In both cases approximately four weeks' worth of usable data were successfully collected.

Instrumentation

9.6.2 The instruments used for automatic noise monitoring during both survey campaigns were Rion NL-32 or NL-52 data logging sound level meters, each fitted with a type UC-59 condenser microphone and a shower-proof outdoor windshield assembly with a double screen. The microphones were mounted on robust stands at a height of 1.2 metres above ground. Each sound level meter was

powered by high-capacity battery packs, housed with the meter in a sealed weatherproof case to prevent tampering. Ambient noise levels expressed in the form of $L_{A90,10min}$ values dB were recorded continuously 24 hours a day throughout the survey period. The results were downloaded to a laptop PC at the end of the survey. Details of all instruments are shown in Table 9.1.

Table 9.1 – Noise Measuring Equipment

Meter	Serial numbers of meter, microphone	Calibrated by, date	Deployed at
Rion NL-32	1193084, 315704	ANV, 16 January 2012	N1 Westerhouse
Rion NL-32	103137, 316490	ANV, 2 February 2012	N2 Station House
Rion NL-32	1182906, 315425	ANV, 24 January 2012	N3 6 Middlemuir Road
Rion NL-52	121670, 318723	ANV, 23 July 2014	N1 Westerhouse (2015)

9.6.3 The calibration of the instruments was checked before and after the measurements using a Bruel & Kjaer type 4231 electronic calibrator, serial no. 1934427. No calibration drift was observed. All measuring equipment had been subject to laboratory calibration traceable to national standards within the previous 12 months, as shown in Table 9.1. The calibrator was subject to an annual laboratory calibration.

9.6.4 Wind data during the 2012 survey were obtained from a temporary meteorology mast installed for the purposes of the background noise survey. It recorded ten-minute means of the wind speed and wind direction on site by means of an anemometer and wind vane 10 m above ground level. The wind data were logged and time stamped relative to GMT, thus facilitating synchronisation with the background noise data. The later installation of a 50 m meteorology mast allowed long-term wind shear data to be used to adjust the 10m wind speeds, in order to allow for site-specific wind shear as required by the IOA Good Practice Guide. Data from the same 50 m mast were later used to obtain the derived wind speeds at 10m height during the 2015 background noise survey, using the methodology recommended in the IOA Good Practice Guide.

9.6.5 A tipping bucket type rain gauge with electronic logging device was installed at one of the noise measurement locations in each case: the garden of 6 Middlemuir Road (2012) and the yard of Westerhouse (2015). Rainfall data were also downloaded to a laptop at the end of each survey.

Measurement and Prediction Locations

9.6.6 Locations for the measurement of background noise levels in proximity to the Proposed Development are shown in Table 9.2 and Figure 9.1. These locations were selected to be representative of outdoor amenity areas of the closest residential properties facing the turbines. Photographs of the monitoring locations are provided at Appendix 9.1. The data logging sound level meters were placed as far as practicable at a minimum distance of 3.5 m from any reflective surface such as buildings and vertical walls, generally in areas which might be used for outdoor relaxation in warm weather, and away from sources of extraneous noise such as farm machinery, watercourses or wooded areas.

Table 9.2 – Noise Measurement Locations

No.	Location	Easting	Northing	Dates
N1	Westerhouse	282815	633495	3 July – 1 August 2012
N2	Station House	282082	630957	3 July – 1 August 2012
N3	6 Middlemuir Road	281014	634436	3 July – 1 August 2012
N1	Westerhouse	282822	633491	26 March – 27 April 2015

9.6.7 The locations at Westerhouse differed slightly on the two surveys because property in the yard had been moved in the intervening period, but the two locations were only 8 m apart and both were in the yard behind (east of) the property. The rain gauge was also deployed in this area for the 2015 survey. There were no obvious sources of noise apart from occasional distant road traffic.

9.6.8 The location at Station Road was in the garden to the west of the property's south-western corner, on previously cultivated ground. The location is largely surrounded by open fields used for pasture. Occasional turbine noise was detected from the Hagshaw Hill Wind Farm to the west, but only when the wind direction was such that the turbines were upwind of the location.

9.6.9 The location at 6 Middlemuir Road was behind the single-storey dwelling on a paved area. It would have been preferable to locate the meter on the grassed area to the front (east) of the property, but satisfactory arrangements could not be made for the security of the instrument in that location. The rain gauge was also placed near this noise monitor for the entire duration of the 2012 survey.

9.6.10 Locations selected for the calculation of noise levels from the Proposed Development are set out in Table 9.3 and shown in Figure 9.1.

Results of Background Noise Surveys

9.6.11 The results of the automatic monitoring of noise and wind speed are presented graphically in the Appendices to this Chapter. Appendix 9.2 shows the noise level and wind speed histories. The *ETSU-R-97* guidance does not provide a method for disregarding 'doubtful' data, but the *IOA Good Practice Guide* recommends a method for discarding data points which may possibly be affected by rainfall. Data regarded as doubtful because of rainfall or other extraneous noise is included in the time histories, but was discarded thereafter. It can be seen that the measured noise levels at all locations were dependant mainly on the wind speed.

9.6.12 The following method was used to reduce the time history data for each measurement location into a format for which the best practice method for determining background noise curves could be used.

- With the data in chronological order, a level versus time graph is plotted for each noise measurement location (a time history). A time history of the derived wind speed at 10 m height is also plotted on each.
- All normal daytime periods are removed (07.00h to 18.00h on weekdays, and 07.00h to 13.00h on Saturdays).
- The remaining data points are divided into two periods, 'night-time' being 23.00h to 07.00h daily, and 'daytime amenity periods' being all the remaining data.
- Points which were possibly affected by rainfall according to the rain gauge time history, and the preceding 'dry' data point before each registered bucket tip signifying rainfall (however slight) are removed.
- A graph is plotted for each location, for each period (daytime amenity or night-time), showing the background noise level against the derived ten-minute wind speed at 10 m height (an x-y plot).

9.6.13 Appendix 9.3 shows scatter plots for daytime amenity periods and night-time periods at each of the noise monitoring locations, with noise levels plotted against the adjusted wind speed, and doubtful data removed. The best-fit curve is superimposed on the data in each case in order to derive the typical wind-dependant background noise levels as recommended by *ETSU-R-97* and the *IOA Good Practice Guide*.

9.6.14 The spread of wind directions occurring during the two background noise survey periods is shown in Appendix 9.4. The wind direction in July 2012 was mostly from the west or south-west, but with significant periods of easterly winds. In April 2015 the wind direction was mainly between westerly and southerly, with relatively little wind from the east or north. In both cases a wide range of wind speeds occurred, resulting in data sets which were fit for purpose.

9.6.15 ETSU-R-97 provides for the use of proxy locations where it is considered unnecessary or impractical to conduct background noise measurements at all potential noise receptors. The IOA Good Practice Guide says that when choosing a location that will serve as a proxy for others, the basis for selection is that it can reasonably be claimed, from inspection and observation, to be representative of the non-surveyed locations, in line with the guidance on measurement site selection. No general guidance is offered on the number of measurement locations because this is necessarily site-specific. The scheme adopted for proxy locations for the Proposed Development is shown in Table 9.3. Noise sensitive receptor locations are shown on Figure 9.1.

Table 9.3 – Noise Prediction and Proxy Background Noise Measurement Locations

Receptor	Name	Uses background curves from
R1	Westerhouse	N1 Westerhouse (2015)
R2	Station House	N2 Station House (2012)
R3	6 Middlemuir Road	N3 6 Middlemuir Road (2012)
R4	Craigend	N1 Westerhouse (2015)
R5	West Toun House	N1 Westerhouse (2015)
R6	Braehead	N3 6 Middlemuir Road (2012)
R7	Midfield Road	N3 6 Middlemuir Road (2012)
R8	Gardens House	N1 Westerhouse (2015)
R9	Scrogton	N2 Station House (2012)
R10	Braidlea	N2 Station House (2012)
R11	Scrogtonhead	N2 Station House (2012)
R12	Stockhill	N1 Westerhouse (2015)
R13	Gunsgreen	N3 6 Middlemuir Road (2012)

9.6.16 The proposed noise limits, derived from the two background noise survey campaigns, are shown in Table 9.4. Different noise limits apply to daytime and night-time, and the limits are expressed against the derived integer wind speeds at 10 m height on site.

9.6.17 All noise limits derived from the Westerhouse background measurements as a proxy location use the 2015 data set. The noise limits derived from background measurements at Station House are directionally filtered in line with *IOA Good Practice Guide* recommendations: data points for the wind which was in the western quadrant were discarded to remove any risk of corruption by noise from existing turbines to the west of the location.

Table 9.4 – Proposed Noise Limits for the Proposed Development

Name	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s
Daytime (07:00h – 19:00h)									
Westerhouse, Craigend, West Toun House, Gardens House, Stockhill	37	38	39	40	40	40	41	41	41

Name	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s
Station House, Scrogton, Braidlea, Scrogtonhead	38	39	40	42	43	45	47	50	52
Middlemuir Road, Braehead, Midfield Road, Gunsgreen	35	35	37	39	41	43	45	47	48
Night-time (19:00h – 07:00h)									
All locations (refer to Figure 9.1)	43	43	43	43	43	43	43	43	43

9.7 Predictive Calculations

Characteristics of Wind Turbine Noise

9.7.1 Noise from turbines is typically made up of a reasonably steady, broad-band noise of aerodynamic origin, which depends on blade tip speed, and mechanical noise from within the nacelle. On older designs of turbine, there may be a tonal noise element from mechanical components within the nacelle. Modern large turbine designs emit noise primarily of aerodynamic origin, with very little mechanical noise being transmitted into the environment. In general, none of the noise emission is tonal in character. The broadband noise is amplitude modulated, *ie* it varies in amplitude as the three turbine blades rotate, with the maximum modulation occurring on the downward movement of each blade from roughly horizontal to near-vertical. This variation of the instantaneous sound level is accounted for in the noise prediction methodology.

Turbine Sound Power Data

9.7.2 The noise data used in the predictive calculations are those for the Siemens Gamesa SG-3.4-132 turbine (with an assumed hub height of 135m) in its normal operational mode (i.e. not noise-restricted), which is the candidate turbine considered to represent a 'worst case' analysis in terms of noise emission. The method used to obtain sound power data conformed to the IEC 61400-11 standard, the most commonly used procedure, which calls for measurements close enough to the turbine that background noise is insignificant. The data are derived from the manufacturer's published data (specification) for the SG-3.4-132, and an uncertainty of 2 dB was included in the sound power levels used for noise prediction purposes as required by the IoA guidance documents.

9.7.3 The turbines would be configured for a maximum overall sound power level (each turbine, manufacturer's reported test levels plus uncertainty) of 108.2 dB(A) at the reference wind speed (v_{10}) of 8 m/s. The SG-6.0-155PG turbine, which is also worthy of some analysis, has reported overall noise emissions 0.9dB lower than this (refer to Appendix 9.7). The sound power depends on wind speed up to the maximum governed rotational speed of the turbine, and the closest approach of wind farm noise to the limit curve is almost invariably within the 6 to 8 m/s wind speed range. Spectral information for the calculation of excess attenuation over distance was also taken from the manufacturer's specification with an appropriate adjustment to ensure equivalence to the overall warranted level plus uncertainty.

Turbine Locations

9.7.4 The proposed turbine coordinates are shown in Table 9.5.

Table 9.5 – Turbine Coordinates for Noise Predictions

Turbine No.	Easting	Northing	Turbine No.	Easting	Northing
T1	279277	631335	T8	280290	632711
T2	279356	631993	T9	280607	632496
T3	279649	631800	T10	280920	632244
T4	280129	631515	T11	280975	631781
T5	279793	632368	T12	281354	632708
T6	280077	632065	T13	281508	632328
T7	280551	631615			

Calculation Procedure for Wind Turbine Noise

9.7.5 The method adopted for the prediction of noise from the turbines is the *ISO 9613-2:1996* method interpreted in the light of the *IOA Good Practice Guide*. The model assumes sound radiation from a point source with only slight attenuation by ground effects. The attenuation resulting from ground effects and atmospheric absorption varies with frequency and distance, and the predictions are carried out in octave bands with the overall A-weighted levels being calculated from the results. The source sound power levels used for calculation purposes take no account of the available noise reduction methods on the candidate turbine or similar types, although various modifications may be available.

9.7.6 The IOA Good Practice Guide states that in order to give reliable predictions of the aggregate noise levels at receptor locations, certain assumptions should be made. These represent the worst case for noise immission of each receiver, *i.e.* for the condition when the wind blows from the turbines to the receptor. The assumptions are:

- all turbines are directly upwind of the receptor;
- the manufacturer's warranted noise data, or published test data, plus an allowance for uncertainty, are used as input to the acoustical model;
- a ground attenuation factor G = 0.5, representing a mix of soft and hard ground, for G_s, G_m and G_r (the ground types in the source region, middle region and receiver region as defined by *ISO 9613-2*);
- the noise source of each turbine is concentrated at turbine hub height; and
- a receptor height of 4 m, corresponding to a first-floor window (note that this conflicts with *ETSU-R-97* recommendations).

9.7.7 In order to calculate the steady noise from the proposed wind turbines the effect of each turbine at each receptor location is calculated. *ETSU-R-97* suggests that the steady nature of the noise emitted by wind turbines is such that the level difference between L_{Aeq} and L_{A90} is typically 2 dB, and this has been confirmed by readings from several turbines in various types of terrain; the approach is advocated by the *IOA Good Practice Guide*. A 2 dB deduction was therefore made from the overall sound power level to yield the typical L_{A90} for calculation purposes. The direction of the wind makes the noise from the turbine effectively directional, since the noise level at a given distance upwind of the turbine will be considerably lower than at the same distance downwind.

9.7.8 The IOA Good Practice Guide also provides guidance on the screening effects of barriers to the propagation of sound, and the effects of the landform between turbine and receptor. A wireframe visualisation of the proposed turbines viewed from each of the receptor locations was reviewed, and where no part of a turbine will be visible, a deduction of 2 dB was made from the contribution

of that turbine to allow for screening by the landform. In many cases the reduction in noise contribution may be considerably greater, but for robustness a maximum of 2 dB was deducted.

9.7.9 The OS grid coordinates of the noise prediction locations are shown in Table 9.6 (and Figure 9.1). The coordinates were selected to represent the nearest point to any turbine within the curtilage of the property named, with the exception of R13 Gunsgreen. This is a location in the centre of an area for which Planning Permission in Principle has been granted for a housing development, although no houses have yet been built and the likely disposition of the buildings on site, house types *etc,* and any landform screening is not known.

Table 9.6 –Coordinates for Noise Prediction Locations

Receptor	Easting	Northing	Receptor	Easting	Northing
R1 Westerhouse	282803	633471	R8 Gardens House	283990	632358
R2 Station House	282083	630975	R9 Scrogton	282644	630470
R3 6 Middlemuir Road	281014	634402	R10 Braidlea	282943	631012
R4 Craigend	282805	633537	R11 Scrogtonhead	282275	630245
R5 West Toun House	282860	633779	R12 Stockhill	278470	634124
R6 Braehead	281196	634407	R13 Gunsgreen	280950	634100
R7 Midfield Road	281486	634486			

Results of Noise Predictions

9.7.10 The predicted worst-case noise levels at the receptor locations from the Proposed Development are presented graphically in Appendix 9.5. The curves shown represent the assumed prevailing background noise characteristic, the aggregate turbine noise and the proposed daytime or night-time noise limit curves applied at each location as appropriate. The results are also shown to the nearest whole decibel in Table 9.7. The amount by which the Proposed Development considered in isolation complies with the proposed noise limits are presented in Table 9.9. Cumulative noise effects are discussed in Section 9.9 of this chapter.

Table 9.7 – Predicted Worst-case Noise Immission Levels dB $L_{A90,10min}$ Against 10 m Wind Speed

Receptor	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s
Westerhouse	24	29	32	32	32	32	32	32	32
Station House	26	32	34	35	34	34	34	34	34
6 Middlemuir Road	23	28	31	31	31	31	31	31	31
Craigend	23	29	31	32	32	32	32	32	32
West Toun House	22	28	30	31	31	31	31	31	31
Braehead	22	28	30	31	31	31	31	31	31
Midfield Road	22	27	30	30	30	30	30	30	30
Gardens House	19	24	26	27	27	27	27	27	27
Scrogton	22	27	30	30	30	30	30	30	30
Braidlea	22	28	30	31	30	30	30	30	30
Scrogtonhead	22	28	30	31	31	31	31	31	31

Receptor	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s
Stockhill	22	27	30	30	30	30	30	30	30
Gunsgreen	25	30	32	33	33	33	33	33	33

9.8 Assessment of Potential Effects

9.8.1 All receptor locations are assumed to be noise-sensitive. The magnitude of change in noise levels depends on the degree to which sounds from the turbines exceed the prevailing background sound level, and thus on how audible the sound may be under different wind conditions.

Construction

9.8.2 During the construction of the turbines there will inevitably be additional road traffic in the vicinity of the site, but vehicle routes will be carefully prescribed in consultation with SLC, in order to minimise disruption and disturbance. The frequency and numbers of such vehicle movements will be insufficient to affect the road traffic noise experienced by local residents, and site access will be gained directly from the national motorway network (with the exception of timber removal from the Forest as is presently the case) avoiding the need for any construction traffic to pass through any local villages: therefore there will be no significant effects on the local road network in residential areas. The permitted hours for deliveries and for working hours on site can be limited by planning condition.

9.8.3 Detailed ground investigations will be undertaken at a later stage of project development, prior to construction. Piled foundations are not anticipated, and conventional gravity foundations will be used. The installation process involves ground excavation, placement of steel reinforcement, and concrete pouring. The process is relatively quiet, with the typical 360^{o} excavator emitting a maximum noise level of around 85 dB(A) at a distance of 5 m. There will also be on site, from time to time, tipper lorries to remove spoil, and other lorries to deliver materials. Each of these events will be short-lived, and the noise levels emitted by the machinery will be comparable with those for an agricultural tractor. Since the operations will be restricted to the normal working day, and because of the separation distances between turbines and local noise-sensitive locations, no significant noise will be received at residential properties.

9.8.4 The effects of distance, ground effects and air absorption mean that at the nearest residential property, the minimum separation distance to construction of any proposed turbine infrastructure being around 0.72 km, the resulting noise levels will be less than 40 dB L_{Aeq},. Operations at an individual turbine foundation would take no more than a day or two, but even in a flat calm the resulting noise would only slightly exceed the daytime background noise level.

9.8.5 The construction of access tracks will be limited to local ground levelling operations, movement of road stone or gravel by tipper lorry, and compaction of the tracks using rollers. The maximum noise levels from the machinery used will be of the order of 80 dB(A) at 5 m distance, and although the activities may be audible from time to time at the closest noise receptor locations, they will not be intrusive and will only be short-term as that localised stretch of road is made and construction work moves on. The noise from construction is low in magnitude of change and is **not significant**.

9.8.6 Blasting may be used if suitable stone is found on site. There is one borrow pit search area from which stone may be extracted, and if this resource is to be used only a single blast pattern will be required. The minimum separation distance between any potential borrow pit for stone and the nearest non-involved residential property will be over 1 km. It is possible that the peak particle velocity (ppv) from the blast might marginally exceed 1.5 mm/s, this being the typical threshold of detection by a human, but there is no possibility that the BS.7385-2:1993 threshold for cosmetic damage to property, 15 mm/s at a frequency of 4 Hz, will be reached. In any event, the weight of explosive charge required to remove and fragment the rock would be kept to a minimum and the expected ppv calculated from that information. The vibration impact from the single blast pattern is **not significant**.

9.8.7 Vibration from conventional construction operations, whether at wind turbine locations or near site access tracks, will be undetectable beyond a few tens of metres from the vibration source. The vibration arising as a result of the passage or operation of an item of construction machinery, including rock processing and handling machinery, will be such that no ground vibration during construction or rock winning operations will be detectable to a human observer inside neighbouring properties. The levels of vibration inside these properties will be several orders of magnitude lower than the architectural damage criteria given in *BS.7385-2:1993*, and at least two orders of magnitude below the levels perceptible to a human observer. This magnitude of change is negligible, and **not significant**.

Operation

Table 9.8 – Predicted Margins of Compliance with Present Noise Limits, dB

Receptor	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s
Daytime									
Westerhouse	16	11	8	8	8	8	9	9	9
Station House	19	13	11	10	11	11	13	16	18
6 Middlemuir Road	17	12	9	9	10	12	14	16	17
Craigend	17	11	9	8	8	8	9	9	9
West Toun House	18	12	10	9	9	9	10	10	10
Braehead	18	12	10	9	10	12	14	16	17
Midfield Road	18	13	10	10	11	13	15	17	18
Gardens House	21	16	14	13	13	13	14	14	14
Scrogton	18	13	12	14	16	17	18	20	21
Braidlea	18	12	12	13	16	17	18	20	21
Scrogtonhead	18	12	12	13	15	16	17	19	20
Stockhill	18	13	10	10	10	10	11	11	11
Gunsgreen	15	10	8	7	8	10	12	14	15
Night-time									
Westerhouse	19	14	11	11	11	11	11	11	11
Station House	19	13	11	10	11	11	11	11	11
6 Middlemuir Road	20	15	12	12	12	12	12	12	12
Craigend	20	14	12	11	11	11	11	11	11
West Toun House	21	15	13	12	12	12	12	12	12
Braehead	21	15	13	12	12	12	12	12	12
Midfield Road	21	16	13	13	13	13	13	13	13
Gardens House	24	19	17	16	16	16	16	16	16
Scrogton	21	16	13	13	13	14	14	14	14
Braidlea	21	15	13	12	13	14	14	14	14

Receptor	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s
Scrogtonhead	21	15	13	12	12	13	13	13	13
Stockhill	21	16	13	13	13	13	13	13	13
Gunsgreen	18	13	11	10	10	10	10	10	10

9.8.8 The noise immission levels from the 13 turbines will fall well within the existing noise limits derived according to ETSU-R-97 and the IOA Good Practice Guide: the levels of noise immission from the Proposed Development will be at least 8 dB lower than the noise limits for existing developments. It follows that the magnitude of change is negligible, and the effect of noise from the proposed wind turbines on local receptors is **not significant**. The cumulative effects of the Proposed Development and all other relevant wind farms in the area are considered below.

9.8.9 Ground-borne vibration from wind turbines is neither discernible by a human observer, nor measurable under normal circumstances, at distances greater than a few tens of metres from the turbine. The magnitude of change in vibration is therefore negligible, and the significance of effect is therefore **none**.

9.8.10 ***Decommissioning***

9.8.11 The noise impact during decommissioning and removal of the turbines will be no greater or more significant than that during construction, and therefore **not significant**.

Requirements for Mitigation

9.8.12 Although no noise mitigation measures are indicated to be necessary, it is possible to mitigate the noise impact of a turbine or turbines under certain operating conditions. Particular wind speeds with the wind blowing from a particular sector will give rise to 'worst case' noise impacts, and under such conditions it will be possible to reduce the noise emissions from individual turbines under software control. These mitigation measures do not need to be specified in advance of turbine construction and can be implemented and adjusted as necessary in order to meet noise limits imposed by planning conditions.

9.8.13 The need for operational mitigation measures will be established as part of the post-construction commissioning process, and will involve noise limit compliance measurements.

9.8.14 Noise mitigation during the construction phase of the turbines and infrastructure will be accomplished by limiting the permitted hours of work, and of deliveries to site by HGV (although abnormal loads will be excepted). Permitted hours of 07:00h to 19:00h daily, and 07:00h to 13:00h on Saturdays, are considered appropriate.

Assessment of Residual Effect Significance

9.8.15 Following implementation of mitigation measures, the construction noise effects on noise-sensitive receptors are assessed as **not significant**. Operational noise effect of the Proposed Development is assessed as **not significant**.

Limitations to Assessment

9.8.16 The assessment is based on best practice guidelines at the time of writing and the worst-case scenario was modelled using the candidate turbine type and likely configuration. There may be variations in the instantaneous sound levels from turbines which mean that they may be heard from time to time by a casual observer.

9.10 Cumulative Assessment

Methodology

9.10.1 There are several operational and consented wind farms within approximately 5 km of the Proposed Development. Those considered of relevance to the cumulative noise assessment are:

- the Douglas West Wind Farm, consented, 13 turbines;
- the Hagshaw Hill Wind Farm, operational, 26 turbines;
- the Hagshaw Hill Wind Farm Extension, operational, 20 turbines;
- the Dalquhandy Wind Farm, consented. 15 turbines;
- The Cumberhead Wind Farm, consented, 11 turbines (+5 bases)
- the Nutberry Wind Farm, operational, 6 turbines;
- the Galawhistle Wind Farm, operational, 21 turbines;
- the Poniel turbines, consented, 3 turbines; and
- the Hazelside turbines, consented and one operational, 2 turbines.

9.10.2 In the case of both Dalquhandy and Cumberhead, new applications have recently been made to amend the currently consented schemes to use larger turbines, and in the case of Cumberhead to change from 11 to 14 turbines. Both applications are currently in planning. In terms of the existing Hagshaw Hill Wind Farm (excluding Extension) an application to replace the existing 26 turbines with 14 new (larger) ones is currently in planning. The future turbines, rather than the operational or consented turbines, were used for noise modelling.

9.10.3 The OS grid coordinates used for the prediction of noise from each project are shown in Appendix 9.6, and the locations of the turbines can be seen in Figure 3.2. The sound power data assumed for cumulative noise modelling are also shown in Appendix 9.6.

Table 9.9 – Worst Case Cumulative Noise Immission Levels, dB

Receptor	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s
Westerhouse	30	35	38	39	39	39	39	39	39
Station House	33	38	41	42	42	42	43	43	43
6 Middlemuir Road	30	35	37	39	39	40	40	40	40
Craigend	30	35	38	38	39	39	39	39	39
West Toun House	28	33	36	37	37	38	38	38	38
Braehead	30	35	37	38	39	39	39	39	39
Midfield Road	28	33	36	37	37	38	38	38	38
Gardens House	26	30	34	35	36	36	36	36	36
Scrogton	29	34	37	37	38	38	38	38	38
Braidlea	29	34	37	38	38	38	38	38	38
Scrogtonhead	30	35	38	39	39	39	39	39	39
Stockhill	33	38	40	42	43	43	43	43	43
Gunsgreen	31	36	39	40	40	40	40	40	40

Table 9.10 – Worst Case Compliance with Noise Limits, dB

Receptor	4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s	11m/s	12m/s
Daytime									
Westerhouse*	15	10	7	6	6	6	6	6	6
Station House	12	7	6	5	6	8	9	11	13
6 Middlemuir Road	5	0	0	0	2	3	5	7	8
Craigend	7	3	1	2	1	1	2	2	2
West Toun House	9	5	3	3	3	2	3	3	3
Braehead	5	0	0	1	2	4	6	8	9
Midfield Road	7	2	1	2	4	5	7	9	10
Gardens House	11	8	5	5	4	4	5	5	5
Scrogton	9	5	3	5	5	7	9	12	14
Braidlea	9	5	3	4	5	7	9	12	14
Scrogtonhead	8	4	2	3	4	6	8	11	13
Stockhill*	12	7	5	3	2	2	2	2	2
Gunsgreen	4	-1	-2	-1	1	3	5	7	8
Night-time									
Westerhouse*	15	10	7	6	6	6	6	6	6
Station House	12	7	4	3	3	3	2	2	2
6 Middlemuir Road	13	8	6	4	4	3	3	3	3
Craigend	13	8	5	5	4	4	4	4	4
West Toun House	15	10	7	6	6	5	5	5	5
Braehead	13	8	6	5	4	4	4	4	4
Midfield Road	15	10	7	6	6	5	5	5	5
Gardens House	17	13	9	8	7	7	7	7	7
Scrogton	14	9	6	6	5	6	6	6	6
Braidlea	14	9	6	5	5	6	6	6	6
Scrogtonhead	13	8	5	4	4	5	5	5	5
Stockhill*	12	7	5	3	2	2	2	2	2
Gunsgreen	12	7	4	3	3	3	3	3	3

A negative value indicates an excess of noise immission level over the applicable limit.

** 45dB limit assumed because of financial involvement with a wind farm other than the Proposed Development*

9.10.4 For initial screening purposes, all turbines in the projects listed above (taking the 'worst case' variants for the existing Hagshaw, Cumberhead and Dalquhandy schemes as being the applications currently in planning), as well as the 13 turbines making up the Proposed Development, were regarded as a single development using various different turbine types as appropriate, and the

ISO9613-2 noise prediction methodology was applied on the basis that all turbines are approximately upwind of each receptor in turn. If this approach identified any potential cumulative noise issues then a more detailed assessment could be made, taking into account wind direction.

9.10.5 There will be considerable screening of turbines by the landform, particularly for distant turbines. The *IOA Good Practice Guide* states that under these circumstances it is acceptable, and robust, to deduct 2 dB overall from the contribution of any individual turbine that is not partially or wholly visible from the receiver location. These deductions were made with reference to the wireline visualisations.

9.10.6 The results of the cumulative noise predictions at the thirteen receptor locations used for the assessment, with every relevant turbine within a radius of 5 km of the proposed turbines being included, are shown to the nearest whole decibel in Table 9.9. These results are compared with the proposed noise limits for the Proposed Development in Table 9.10. This can be considered a broad-brush approach to the recommendations of *the IOA Good Practice Guide*, and includes 2 dB of screening for any turbine not visible from the location in question. No allowance is made for directivity, and every turbine was treated as if it were directly upwind of the receptor at a single point in time, which in reality would never be the case.

Results and Commentary, Cumulative Noise Levels

9.10.7 This broad-brush approach exaggerates the cumulative noise effects, because as can be seen from Figure 3.2, there are no receptor locations that can ever simultaneously fall downwind of every wind farm in the locality. Nevertheless, the proposed noise limits for the Proposed Development can be met under these circumstances at all but one of the receptor locations used in the present study, by all turbines listed in paragraph 9.9.1 and the Proposed Development turbines, with the sole exception being the consented (but unbuilt) housing development at Gunsgreen.

9.10.8 The predicted exceedance shown in Table 9.10, at the permitted housing at Gunsgreen using the broad-brush approach is slight and would be applicable during daytime and evening hours (not at night). The layout of proposed dwellings at Gunsgreen is not yet known, but acoustical screening within the housing estate will tend to reduce the levels and, as noted above, the broad-brush approach used exaggerates the cumulative effects as there are no receptor locations (including Gunsgreen) that can ever simultaneously fall downwind of every wind farm in the locality. It is therefore concluded that in reality, should this housing development ever be built in the future, that the noise limits set out in Table 9.4 would be met by the Proposed Development, alone and cumulatively.

9.10.9 Should the final turbine type used for the Proposed Development (and for the Repowered Hagshaw Hill Wind Farm) be the SG-6.0-155PG, as opposed to the SG-3.4-132 modelled, it will either result in a very slight improvement (reduction in level) or will make a negligible difference.

9.10.10 The cumulative noise effect on local receptors is therefore considered to be **not significant**.

9.11 Summary

9.11.1 Baseline noise surveys to establish the pre-existing sound levels at selected local dwellings were not possible or required in this case, due to existing operational wind turbines in the local area. Data from previous noise survey campaigns by the developer led to the noise limits in effect for the consented wind energy development at the neighbouring Douglas West site and these limits provide a noise immission budget within which the Proposed Development must also operate, in accordance with best practice guidance.. The noise immission levels at local noise-sensitive locations were calculated using internationally recognised prediction methods and the robust results were then compared with the relevant noise limits. The design of the Proposed Development was found to be capable of meeting these limits. Its effect on the noise environment experienced by local residents is therefore **not significant**.

9.11.2 The cumulative effects of the Proposed Development, plus all relevant operational and consented wind turbines within 5 km of the proposed turbines, including the Revised Cumberhead Wind Farm,

Revised Dalquhandy Wind Farm and Repowered Hagshaw Hill Wind Farm, were calculated in the same way. The methodology was expected to over-predict the cumulative noise immission levels and the small excess at Gunsgreen (only) over the proposed noise limits is slight, and in practice not significant. The increase in noise from the Proposed Development turbines over that already occurring or likely to occur from operational and permitted wind farms in the locality will be subjectively unnoticeable at most locations, and within acceptable limits. The overall effect is therefore **not significant**.

Table 9.9 – Summary Table

Description of Effect	Significance of Potential Effect		Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial/ Adverse		Significance	Beneficial/ Adverse
Construction noise	Not Significant	Adverse	Control of working hours and best working practices	Not Significant	Adverse
Operational noise from Proposed Development	Not Significant	Adverse	Operational monitoring to ensure compliance, with the option of selective constraint of turbine operation if found to be a requirement.	Not Significant	Adverse
Cumulative noise from the operation of consented and proposed local wind energy developments	Not Significant	Adverse	Operational monitoring to ensure compliance, with the option of selective constraint/or Douglas West Extension if found to be a requirement.	Not Significant	Adverse

9.12 References

The Working Group on Noise from Wind Turbines (1996). *ETSU-R-97 The Assessment and Rating of Noise from Wind Farms. Energy Technology Support Unit*, DTI.

Institute of Acoustics (2013) *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*.

British Standards Institute (2009) *BS.5228-1 Code of practice for noise and vibration control on construction and open sites – Part 1: noise*. BSI.

International Standards Organisation (1996). ISO 9613-2 Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation..

Bowdler D, Bullmore A, Davis R, Hayes M, Jiggins M, Leventhall G, McKenzie A (2009) Prediction and assessment of wind turbine noise. Acoustics Bulletin vol.34 no.3 pp35-37. Institute of Acoustics.

Scottish Government (2011). *Planning Advice Note 1/2011: Planning and Noise*. Available at: http://www.gov.scot/Publications/2011/02/28153945/0.

UK Government (1974). *Control of Pollution Act*. HMSO

This page is intentionally blank.